MOVING TOWARD ACTIVE, SAFE, AND SUSTAINABLE TRANSPORTATION IN ADDISON COUNTY, VT

ENVS 401 Senior Seminar Spring 2018

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LIST OF ACRONYMS

AADT	Average Annual Daily Traffic
AATT	Average Annual Truck Traffic
ACRPC	Addison County Regional Planning Commission
BLTS	Bike Level Traffic Stress
GHG	Greenhouse Gas Emissions
GIS	Geographic Information System
PCM	Pairwise Comparison Method
VT CEP	Vermont Comprehensive Energy Plan
VTrans	Vermont Agency of Transportation
WBCAC	Walk-Bike Council of Addison County

EXECUTIVE SUMMARY

This report was formulated by members of the Middlebury College Environmental Studies Senior Seminar in correspondence with the Addison County Regional Planning Commission (ACRPC), Walk-Bike Council of Addison County (WBCAC), and Local Motion.

As previous research has demonstrated, walking and biking can have several positive benefits ranging from improved health for those who walk and bike regularly, to reductions in greenhouse gas emissions spurred by corresponding reduced automobile use. The latter makes improving biking and walking infrastructure especially important in Vermont, where the state's Comprehensive Energy Plan (VT CEP) has set the goal of achieving 90% renewable energy use by 2050. Unfortunately, Vermont's current road infrastructure is not particularly well-suited to providing safe conditions for alternative transportation users, with abundant shared-road infrastructure gaps across the state.

This study seeks to investigate where the biggest infrastructure weaknesses and social conflicts are related to shared road use throughout Addison County. Taking both a qualitative and quantitative approach, the study employs three major methods of data collection: focus groups, survey distribution, and Geographic Information System (GIS) analysis. The first of these methods, consisted of conducting two focus groups with bikers and one focus group with non-biker-identifying motorists. Information gleaned from these groups, which included physically marked up maps detailing "safe" and "unsafe" roads as well responses to questions about infrastructure and language used on road signs, was utilized in order to assist in designing a comprehensive survey which was subsequently distributed to residents of Addison County via Front Porch Forum (an online, Vermont community-building service) and the Bristol Trail

Network mailing list. Simultaneously, GIS analysis was used to study the safety of roads throughout the county for biking, using Bike Level Traffic Stress (BLTS) methodology.

Results of the focus groups and survey demonstrated that the most desirable attributes for highway and town roads according to both motorists and bicyclists were wide shoulders and proper shared-road etiquette, while traffic speeds too high to have safe share-road interactions was another commonly cited grievance. Roads identified as having the most conflict included College Street, Cross Street, River Road, and US Route 7, all of which received the vote of at least 40% of respondents. In addition to this data, GIS analysis using BLTS methodology determined a Tri-Town Biking Loop representing the safest route for bicyclists between Addison County's three major towns: Vergennes, Middlebury, and Bristol.

The study recommends that future funding and advocacy efforts be directed towards improving shared road infrastructure through the widening of shoulders, stricter enforcement of speed limits, and paving of dirt roads such as the stretch of Plank Road linking Bristol to New Haven. Additionally, the study recommends an increased focus on education throughout the county about proper shared roadway etiquette and increased partnership with existing groups focused on road safety such as Safe Routes to School in Middlebury.

INTRODUCTION

Background

Since Henry Ford began producing the Model T, cars, trucks, and motorcycles, motor vehicles have become an integral part of American transportation. Vermonters are particularly reliant on motor vehicles for transportation due to the rural nature of the state. In 2010 alone, people in Vermont travelled over seven billion miles in motor vehicles. It should come as no surprise, then, that 47% of the state's greenhouse gas (GHG) emissions come from the transportation sector (VT CEP, 2016).

A growing body of literature surrounding the climatic effects of GHGs illustrates a need for substantial reductions in the use of GHG-producing processes to avoid large environmental changes that could prove catastrophic for many people. In response, Vermont has set several ambitious goals pertaining to the reduction of GHG emissions by 2030, including a 20% reduction of single-occupancy vehicle trips, a 110% increase in public transit ridership, and a 100% increase in bike and pedestrian commuter trips (VT CEP, 2016).

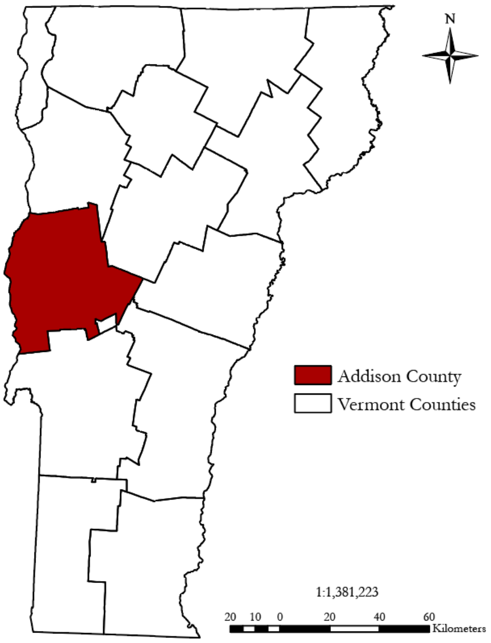
Increasing the prevalence of biking and walking not only supports state goals to reduce GHG emissions but also improves community health and well-being, as well as provides alternative transportation opportunities particularly among those without access to cars including children and youths and low-income individuals.

Studies suggest that individuals who live in neighborhoods with greater walkability and bikeability are significantly more likely to walk or bike, resulting in a reduction in the prevalence of obesity, diabetes, and other related health conditions (Glazier et al., 2014). Communities may additionally benefit from improved air quality. In a study of land use in King County, Washington, researchers found a 5% increase in walkability to be associated with 5.6% fewer grams of nitrogen oxides (NOx) emitted, and 5.5% fewer grams of volatile organic compounds (VOC) emitted (Frank et al., 2006).

Increased prevalence of walking and bicycling can also have positive effects on community safety and desirability. Furthermore, higher numbers of walkers and cyclists can stimulate economic activity and tourism by increasing traffic to downtown areas, thereby providing a boost to local economies (VT CEP, 2016).

Biking and Walking in Addison County

Figure 1: Study Area



Addison County is in the westernmost part of Vermont adjacent to Chittenden County in the north, Orange County in the east, and Rutland County in the south (See Figure 1). It constitutes 6% of the State's estimated total population in 2016 (US Census Bureau). Of the 23 towns in the county, Bristol, Middlebury, and Vergennes are the most populated towns with the best-performing economies.

Most bicycle and pedestrian facilities in the County are concentrated in major downtowns of Bristol, Middlebury, and Vergennes to accommodate intra-town movements of a larger number of population who need to travel shorter distances within the town community. According to Addison County Regional Planning Commission (ACRPC), people are generally willing to walk if the destination is between half and one mile far from the origin, and bike if the distance is between 2 to 5 miles. That is why bicycle and pedestrian infrastructures rarely exist beyond the town centers due to low commuter usage and demand (ACRPC, 2018). Thus, both long-distance commuter and recreational bicyclists often run the risk of bicycling without designated bike lanes or presence of wider road shoulders that would allow them to bike comfortably and safely.

Throughout the county, the number of cyclists and pedestrian-related accidents significantly increased from zero deaths in the early 2000s to four deaths early 2010s, which alarmed concerned residents and prompted various community dialogues regarding pedestrian and bicycle safety (VTrans Crash Data). Due to these recent accidents, perceptions of safety became critical as many people expressed not feeling safe biking and walking on shared roads with motorists. Likewise, motorists have some reservations with regards to sharing roads with cyclists and pedestrians due to the current lack of bicycle and pedestrian infrastructures particularly the narrow shoulders on most roads. Safety concerns and infrastructure issues are not unique to Addison County. Because of the rural geographic nature of the state, integrating bicycle and pedestrian facilities is immensely challenging.

Project Partners and Objectives

The Walk-Bike Council of Addison County (WBCAC), a group dedicated to improving bicycling and walking infrastructure in Addison County, and Local Motion, an advocacy group for bicycling and walking in Vermont, have partnered with our group to provide us with relevant information and expertise on bicycling and walking initiatives in the county. After a series of meeting with our project partners, we agreed to support their data collection efforts and provide information that is most useful to them. The following are our project objectives:

1. Gather data regarding cyclist and motorist experience and habits through focus groups and a survey distributed to residents of Addison County.
2. Gather data regarding desirable infrastructure changes that might mediate relationships between cyclists and motorists as well as make bicycling routes more accessible and user-friendly.
3. Determine the best roads for cyclists to travel between major towns in Addison County based on various road and traffic parameters.

METHODOLOGY

Focus Group Sessions

In considering ways in which the specificity of the survey could be improved, both in-depth interviews and focus groups were considered as means of gaining more preliminary perspective on issues of walkability and bikeability across Addison County. Though both methods of qualitative research have their benefits, it was decided that focus groups provide the group dynamic required to better analyze and understand not only infrastructure issues related to walking and bicycling accessibility, but also cultural and social issues as well.

The study was constructed using a multi-category design consisting of three separate focus groups: two in which the participants were cyclists, and one in which the participants were automobile drivers who do not ride bicycles.

The first biker focus group was conducted on Thursday, April 5th at the Addison County Regional Planning Commission office in downtown Middlebury and consisted of nine members of the Addison County Walk-Bike Council, the dominant demographic of which was white and middle-aged, while the second biker focus group was conducted on Monday, April 30th at the Middlebury College Hillcrest Environmental Center, and consisted of three non-council members of a similar demographic to the first group. The motorist focus group was conducted on Friday, April 6th at Vermont Field Sports and consisted of four participants.

Survey Design and Distribution

A survey was distributed among New Haven residents in 2017 by the Walk-Bike Council of Addison County to collect information regarding current bicycling and walking habits, as well as what infrastructure features might encourage people to travel by these means more frequently. We used the original version of this survey as a base for our own data collection, modifying it as we saw fit to collect information relevant to bicycling infrastructure development in Addison County.

The original survey distributed to New Haven residents did not elicit the opinions of motorists regarding bicycling infrastructure. Because driving is the predominant mode of transportation in Vermont, we thought it was important to consider the opinions and desires of motorists when crafting a spatially explicit plan to improve bicycling access and infrastructure due to the prevalence of motorists in Vermont. It is widely believed that since towns and social centers are widely dispersed across the state's rural landscape, motorists outnumber cyclists in Vermont. While this belief has received little attention in the way of quantitative data, the results of our survey discussed below support this notion. Because of this, we thought it was important to consider the wants and needs of motorists with regards to this issue, as they are the most abundant stakeholders in issues pertaining to Vermont road use. Questions were added to the original survey that addressed the frequency and nature of respondents' motor vehicle travel habits in addition to bicycling infrastructure changes that might make interaction between cyclists and motorists more comfortable for drivers.

We also modified survey questions that asked cyclists, drivers, and walkers about frequently traveled routes. In the original survey, these questions were posed with open-ended prompts and free response type answers. To minimize the time required of respondents to complete the survey and elicit thoughts on specific routes, we opted to remove these open-ended free response questions. Instead, we employed questions that addressed routes identified as exceptionally good or poor routes for bicycling in focus groups with cyclists and motorists of Addison County. The questions surrounding these routes are aimed at gathering more information regarding the frequency of cyclist use of these routes, the frequency of cyclist-motorist conflict on these routes, the nature of such conflicts, and how the bicycling infrastructure along these routes could be improved.

Finally, we added questions that shed light on the demographics of respondents to assess equity of access and use of bicycling infrastructure, as well as more broadly deciphering what demographics the data we gathered came from.

The final version of our survey was distributed to residents of Addison County via Front Porch Forum, and the Bristol Trail Network mailing list.

GIS Modeling of Motorists-Bicyclist Interaction

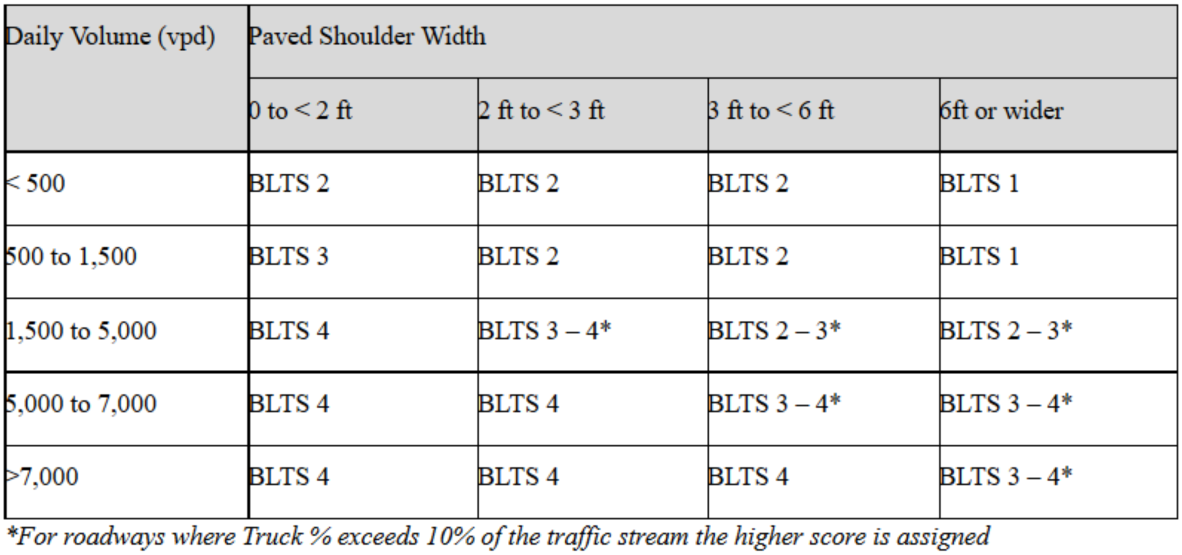
Route selection by cyclists in Addison County is strongly influenced by the perceived risk of sharing the roads with motorists. Since safety concerns remain the biggest barrier to promoting bicycling culture in Vermont, there is an urgent need to model and incorporate bicyclist-motorist interaction studies in transportation planning if Vermont is to meet its transportation sustainability goals. The Bike Level Traffic Stress (BLTS) is one method commonly used in modeling this interaction (Mekuria et al., 2012; Sorton et al., 1994; VTrans, 2018; Wang et al., 2015; Wang et al., 2016).

The BLTS methodology uses data as proxies to represent the subjective feelings of bicyclist perception of comfort on shared roads. Since bicyclists prefer to utilize routes that produce the least amount of physical and mental stress. BLTS mainly uses traffic variables such as traffic volume, truck traffic, and speed to measure bike level comfort (Sorton et al., 1994). The BLTS model was first tested in the U.S. in urban San Jose, California in 2012 by the Mineta Transportation Institute (MTI) (Mekuria et al., 2012; VTrans, 2018). Since then other places, primarily the States of Colorado and Oregon, have implemented the model to assess road traffic and roads' comfortability level for bicycling (VTrans, 2018).

The Vermont Agency of Transportation (VTrans) adapted and implemented BLTS on state roads during the Second Phase of their On-Road Bicycle Plan in 2017. To ensure that they differentiate recreational cyclists, who currently tend to use rural routes, and commuter cyclists, who currently tend to use urban routes, VTrans developed two separate BLTS models specifically modified for rural and urban areas in Vermont. For this study, we decided to use the Rural BLTS Criteria considering that most towns in Addison County are rural. Based on factors that have been identified by VTrans as most important in influencing bicycling comfort levels in Vermont, VTrans BLTS classifies roads into four categories:

- BLTS 1 Roads: Welcoming to Most Bicyclists
- BLTS 2 Roads: Comfortable for Most Adult Bicyclists
- BLTS 3 Roads: Comfortable for Experienced and Confident Bicyclists
- BLTS 4 Roads: Uncomfortable for Most Bicyclists

VTrans Rural BLTS Criteria uses the following variables: (a) presence and/or width of shoulder, (b) estimated daily traffic volume, and (c) estimated truck traffic percentage. Table 1 summarizes the modified BLTS criteria for rural roads in Vermont.



Daily Volume (vpd)	Paved Shoulder Width			
	0 to < 2 ft	2 ft to < 3 ft	3 ft to < 6 ft	6ft or wider
< 500	BLTS 2	BLTS 2	BLTS 2	BLTS 1
500 to 1,500	BLTS 3	BLTS 2	BLTS 2	BLTS 1
1,500 to 5,000	BLTS 4	BLTS 3 – 4*	BLTS 2 – 3*	BLTS 2 – 3*
5,000 to 7,000	BLTS 4	BLTS 4	BLTS 3 – 4*	BLTS 3 – 4*
>7,000	BLTS 4	BLTS 4	BLTS 4	BLTS 3 – 4*

**For roadways where Truck % exceeds 10% of the traffic stream the higher score is assigned*

Table 1: VTrans Rural BLTS Criteria

Road segments and traffic data were provided by Vermont Transportation Agency (VTrans) and Addison County Regional Planning Commissions (ACRPC) respectively. First, we only included Class 2 and 3 local roads in our analysis to identify bicycling infrastructure gaps between current on-road bicycle corridors as identified by VTrans, and densely populated town centers throughout Addison County such as Bristol, Middlebury and Vergennes.

Secondly, the traffic database has records of Annual Average Daily Traffic (AADT) collected from 1958 to 2014, and Annual Average Truck Traffic (AATT) collected from 1994 to 2014. To make the study consistent and more appropriate temporally, we only selected AADT and AATT data collected from 2000 to 2014. The two most recent traffic data collected for each location were averaged to represent the AADT and AATT value that were used to assign the BLTS score. On average, Addison County has AADT ranging from 60 to 34400 daily traffic volume, with AATT accounting for 0 to 14 percentage of truck traffic. Lastly, data on shoulder width was produced by ground truthing with Google Street View to look for presence and absence of road shoulders. Four road segments with presence of shoulders were identified and measured during field work. Road shoulder widths in the county range from 0 to 4 feet (See Appendix A & B for the Metadata and Outline of the GIS Processes).

Tri-Town Biking Loop

The ACRPC 2018 Transportation Draft Plan highlighted the need to focus on long-distance commuting recognizing that a significant number people in the county make a conscious decision to bike to work on a regular basis. Therefore, we worked to identify bikeable routes that connect at least the three major economic centers in the county. This is to inform and support future planning and development of a tri-town biking loop as the county plans on shifting its focus to long-range transportation strategies.

We first identified different route options that connect the three major towns—four route options between Middlebury and Vergennes; three route options between Middlebury and Bristol; and only one route option between Bristol and Vergennes (See Appendix C for the Route Options). In determining which ones of these route options will make up the tri-town biking loop, we looked at four parameters namely traffic stress, distance, topography, and accident history. It is important to note that these four parameters were selected mainly because of its accessibility. Other parameters such as speed and pavement conditions were not available and were also difficult to collect.

For traffic stress, we used the BLTS results which already have information on the presence of road shoulders, traffic, and truck traffic volume. Accident history was gathered from VTrans Crash Query Tool web map, and distance was calculated using GIS. Lastly, for topography, we used Strava, an online app for tracking routes of runners and cyclists, to get elevation gain information which we used to calculate elevation gradient. The identified route options were ranked accordingly, and ranking was assigned a numeric value (See Appendix D for Route Options Ranking).

To determine the relative importance of the parameters, we conducted a separate survey which mainly involved asking random people to rank traffic stress, distance, topography, and accident history according to what they consider most important or influential in choosing roads/routes to bike on. This was conducted in public spaces particularly in Middlebury College libraries, dining halls, and downtown Middlebury. Thirty people, who all claimed to be occasional or frequent cyclists, were solicited to rank the parameters (See Table 1 in Appendix E for the Survey Results).

The ranking results informed how we numerically weighted the four parameters using the Pairwise Comparison Method (PCM) (See Table 2, 3, & 4 in Appendix E for the PCM Calculations). The PCM is a way to evaluate and quantify the relative importance of different options being considered based on the subjective judgment of the decision-maker. The strength of this method is that it systematically compares each option head to head instead of merely ranking options linearly. As a result, options get weighted almost objectively. After ranking the various route options for each parameter and determining the relative importance of the parameters, we then calculated the overall prioritization score by multiplying the rank value and relative importance weights (See Appendix F for the Prioritization Score Formula and Calculations). The route with highest overall score was selected for the composition of the Tri-Town Biking Loop. Figure 2 shows the conceptual workflow described above.

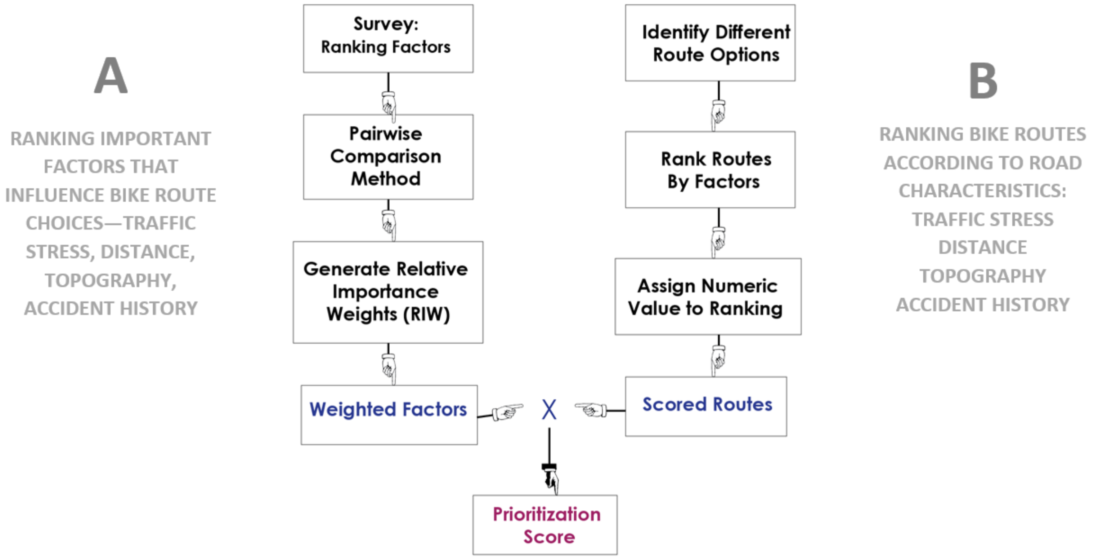

A
RANKING IMPORTANT FACTORS THAT INFLUENCE BIKE ROUTE CHOICES—TRAFFIC STRESS, DISTANCE, TOPOGRAPHY, ACCIDENT HISTORY
Survey: Ranking Factors
Pairwise Comparison Method
Generate Relative Importance Weights (RIW)
Weighted Factors
X
Identify Different Route Options
Rank Routes By Factors
Assign Numeric Value to Ranking
Scored Routes
Prioritization Score
B
RANKING BIKE ROUTES ACCORDING TO ROAD CHARACTERISTICS: TRAFFIC STRESS DISTANCE TOPOGRAPHY ACCIDENT HISTORY

Figure 2: Processes in identifying the Tri-Town Biking Loop

RESULTS

Focus Group: Bicyclists

Below are the questions and activities with which the participants of the Walk-Bike Council focus group at ACRPC were asked to partake in along with a summary of the responses which were given:

1. *As a biker, how would you describe your experience bicycling on Vermont's roads?*

Responses for this question varied greatly, touching on several issues. Most respondents prefaced their comments by articulating the great benefits of bicycling in Vermont with most highlighting the incredible beauty of the state's natural features. Nearly all respondents however had serious concerns about safety, regardless of whether they identified as bike commuters or recreational cyclists. Causes of concerns voiced by the participants ranged from infrastructure gaps between bike friendly areas to aggressive drivers. One individual in particularly cited several deaths that have occurred across the county in the last few years as a deterrent in terms of passing on his passion for bicycling to his kids.

2. *What do the differences among the following four signs indicate to you (See Appendix G) As a biker do you prefer one? Or, as an alternative, can you think of a sign that would better convey how you think the road should be used? What would that look like?*

The first group gravitated towards support for the "may use full lane" sign when choosing between the four options acknowledging that it granted the right of the road to bikes in areas where roads might be too narrow for both cyclists and motorists to operate safely and comfortably.

Between the “share the road” and “shared road” signs, the group unanimously supported the latter, specifically referencing the sign’s less commanding tone as being a positive. When asked to design their own signs or come up with alternatives to the four images that were distributed to them, respondents proposed signs at the outskirts of towns that would let motorists and cyclists know that they are entering a “bike friendly town” or “bike friendly city” as well as signs that would use language such as “pass with care” or “pass bicyclists safety”. A concern that was shared by a few respondents with regards to signage in general was its oversaturation in places such as downtown Middlebury. One participant opined that too much signage makes it harder for cyclists and motorists to know which to heed, and consequently, can create dangerous situations.

The second group, in contrast, thought that the “may use full lane” language was too obnoxious and had the potential to create more hostility from drivers who already view bikers as using too much of the road. Between the “share the road” and “shared road” language, the second group preferred the “shared road” sign, citing the former as sounding too demanding.

3. *What features of a road do you consider when determining whether it is suitable to bike on?*

Across both groups, participants identified the following criteria as being important: shoulder width, cleanliness of shoulders (whether snow and other debris are cleared), traffic volume, gradient of inclines, number of blind curves, and general road surface conditions (potholes, gravel, etc.). Because the participants were not asked to rank these criteria, the importance of each of these may vary depending on the biker.

4. *Using the provided map of Addison County, identify roads which you feel comfortable bicycling on in yellow and roads which you feel uncomfortable bicycling on in red. Afterwards, as a group, identify at least five roads which you find to be the most dangerous and five roads which you find to be the safest.*

See Appendix H and I for results.

5. *If you could suggest one infrastructure change to improve bike safety or convenience that would immediately take effect guaranteed, what would you propose?*

The two most common responses were to lower speed limits across the county and to add mandatory, bike-friendly shoulders to all roads (though the second focus group thought reducing speed limits would have minimal effect). Other responses focused on larger infrastructure projects. For example, one participant suggested that the county use the "complete streets" program into consideration, especially with regards to town center. Several respondents also proposed a county-wide bike trail connecting the major towns in Addison County (Middlebury, Vergennes, and Bristol), citing the potential economic opportunities that could be created by increased biker tourism.

Focus Group: Motorists

To inform the motorist-oriented questions in our survey, identify exemplary and poorly designed shared roads in Addison County, and collect valuable qualitative data regarding the opinions and sentiments of Vermont drivers, a focus group composed of four people identifying driving as their only means of transportation was conducted at Vermont Field Sports in Middlebury. The structure of the motorist focus group was slightly different than cyclist focus groups. Participants were first prompted to mark well-designed shared roads as well as shared roads that were perceived as being places of frequent conflict between cyclists, motorists, and pedestrians on individual maps of paved roads in Addison County.

After all participants had marked their individual maps, a large map of Addison County roads was laid out in front of all participants and individually marked roads were discussed by the group. Any roads that the entire group regarded as well-designed shared roads or places of frequent conflict were marked on the map using markers, with green lines indicating well designed shared roads, and red lines indicating roads of common conflict between cyclists, motorists and pedestrians. Notable agreed upon well designed shared roads include Route 7, Route 22A, Route 30, and Route 74. Notable agreed upon roads of common conflict between cyclists, motorists, and pedestrians include Green Street, Greenbush Road, Maple Street, Route 53, and all roads in downtown Middlebury (See Appendix J for the Map Results).

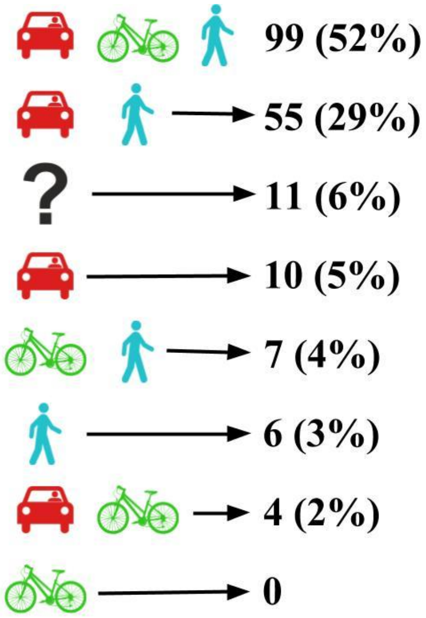
Following the map exercise, participants were prompted to discuss road attributes that they perceive as being good or bad for roads being amiably shared by cyclists, motorists, and pedestrians. Road attributes that were described as conducive to well shared roads include wide road shoulders, road users obeying speed limits, compliance with laws/etiquette of shared roads, low traffic volume, and cyclists and pedestrians travelling single file as far to the side of the road as possible. Conversely, road attributes that were described as being impediments to amiably sharing roads with users of multiple modes of transportation include no/narrow shoulders, blind hills and curves, motorists and cyclists travelling faster than the marked speed limit, motorists and cyclists breaking the laws/etiquette of shared roads (failing to signal turns/stops, cyclists riding multiple abreast while motorists attempt to pass, motorists encroaching upon cyclists, etc.), and high traffic volume.

Next, participants were asked what shared road infrastructure changes might make interactions between cyclists, motorists, and pedestrians more comfortable. Answers were wider road shoulders and buffered bike lanes. During this portion of the focus group, participants made it very clear that many cyclists behave as though they do not have to share the road and take up as much of the lane as they can as though they are proving that they legally can. Additionally, participants said that signs indicating shared roads are not useful, as they do nothing to mediate interactions between shared roads users aside from making it known that these interactions may occur.

Finally, participants were asked to describe how they perceived the relationships in Addison County between cyclists, motorists, and pedestrians. It was well agreed upon that tension and animosity exists between cyclists and motorists. One participant said that this tension between groups may be an artifact of a perceived income disparity between cyclists and motorists, with cyclists generally earning a higher income than people that only travel via motor vehicles, and the other participants agreed. The same participant also made a distinction between recreational cyclists and commuters, saying that commuters tend to ride more defensively whereas recreational cyclists take up as much room as they are allowed and do not move over for motorists travelling faster than them.

Survey Results

Figure 3: Survey Respondents



At the time we analyzed survey data, 192 people had completed or partially completed the survey. Of the respondents, 90% identified as motorist, 58% as cyclists, and 89% as pedestrians. Of the people who identified as motorists, 60% said they also identified as cyclists, and 90% said they also walked on Vermont roads (See Figure 3 for a more detailed description of respondent transportation identifications) (See Appendix K, L, and M for more information regarding survey respondent demographics).

Of the respondents who identified as motorists (n=173), 53% drive more than once per day, 22% drive once per day, 23% drive a few times per week, 1% drive once per week, and 1% drive less than once per week.

Of the respondents who identified as cyclists (n=111) and during the seasons they are comfortable bicycling, 4% bike more than once per day, 13% bike once per day, 50% bike a few times per week, 14% bike once per week, and 19% bike less than once per week.

Of the respondents who said they walk on Vermont roads (n=170) and during the seasons they are comfortable doing so, 27% said they walk more than once per day, 23% said they walk once per day, 38% walk a few times per week, 4% walk once per week, and 8% walk less than once per week (See Figure 4). These results indicate that, while cyclists and pedestrians were relatively abundant among our respondents, the frequency with which people travel by biking and walking is consistently less than that with which people travel by motor vehicles.

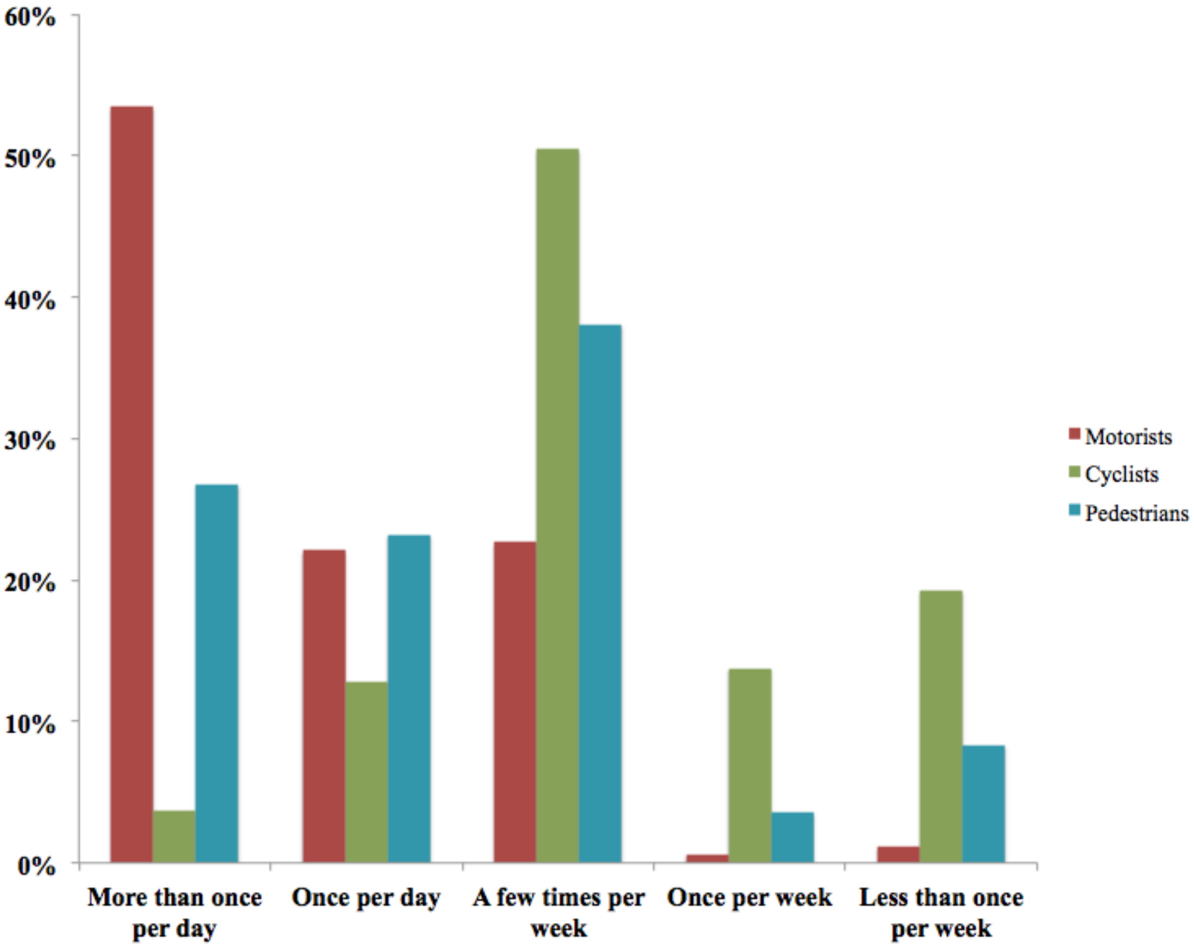


Figure 4: Self-Reported Frequency of Transport Mode Use

Of the respondents who identified as motorists (n=173), 61% drive to get to work or classes, 94% drive to shop or run errands, 16% drive to take kids to school, 17% drive to pass time, 2% drive to get to a public transit stop, 2% drive to get to a carpool or vanpool, 71% drive to get to recreational areas and/or activities, 68% drive to get to community and/or social events, and 16% drive for one or more other reasons (See Figure 5).

Of the respondents who identified as cyclists (n=111) and during the seasons they are comfortable riding, 30% bike to get to work or classes, 44% bike to shop or run errands, 3% bike to take kids to school, 84% bike to pass time, 5% bike to get to a public transit stop, 0% bike to get to a carpool or vanpool, 89% bike to get to recreational areas and/or activities, 37% bike to get to community and/or social events, and 16% bike for one or more other reasons (See Figure 4).

Of the respondents who identified as pedestrians (n=170) and during the seasons they are comfortable riding, 23% walk to get to work or classes, 45% walk to shop or run errands, 4% walk to take kids to school, 87% walk to pass time, 9% walk to get to a public transit stop, 1% walk to get to a carpool or vanpool, 90% walk to get to recreational areas and/or activities, 45% walk to get to community and/or social events, and 19% walk for one or more other reasons (See Figure 5).

Our data regarding reasons for travelling by a given mode of transportation reveal the fact that motor vehicle use is often associated with everyday utilitarian travel while biking and walking are generally associated with irregular travel for recreational purposes.

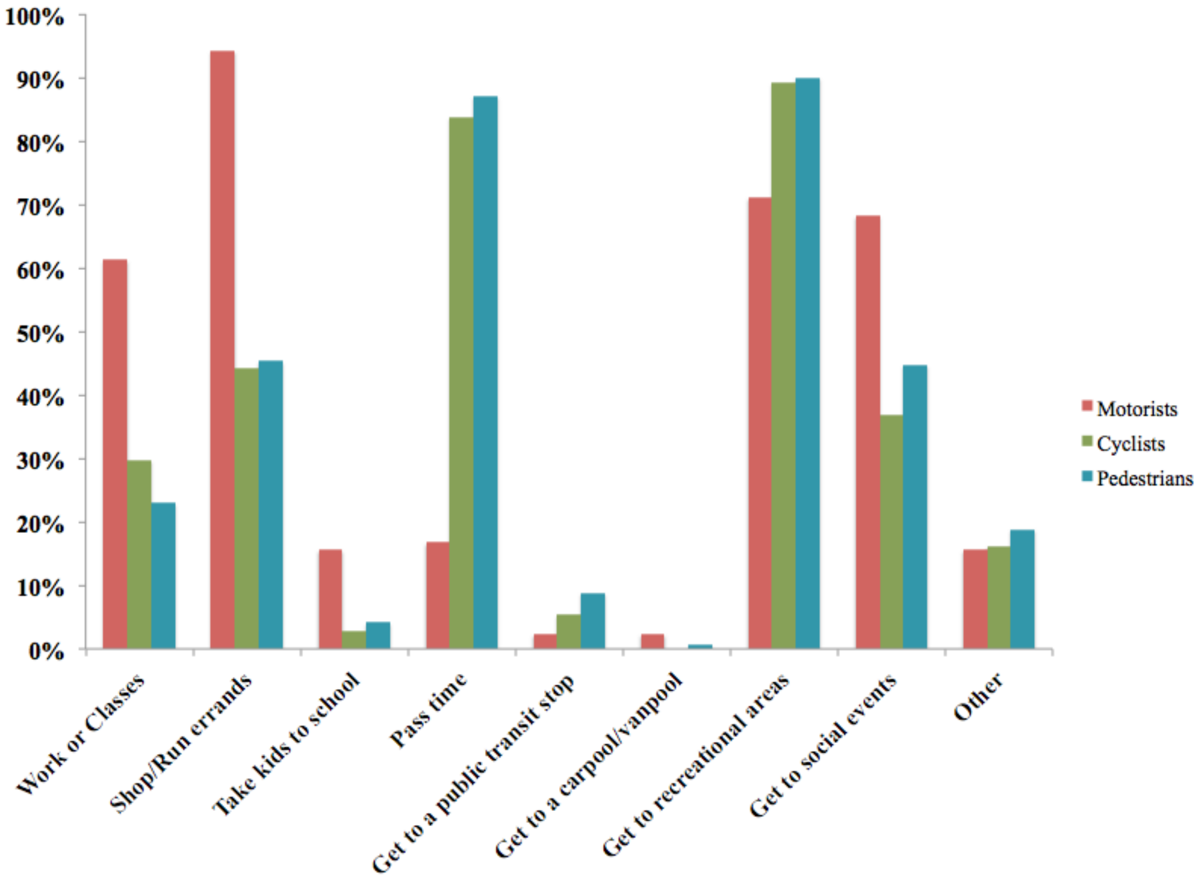


Figure 5. Self-Reported Reason for Traveling by Transport Modes

The highest education levels of motorist respondents who provided education information (n=136) are as follows: 0% have some high school education or less, 3% graduated high school, 1% graduated from vocational/technical school, 9% have some college/university education, 46% graduated college/university, and 41% have graduate degrees.

The highest education levels of cyclists' respondents who provided education information (n=94) are as follows: 0% have some high school education or less, 2% graduated high school, 1%

graduated from vocational/technical school, 9% have some college/university education, 47% graduated college/university, and 41% have graduate degrees.

The highest education levels of pedestrian respondents who provided education information (n=138) are as follows: 0% have some high school education or less, 2% graduated high school, 1% graduated from vocational/technical school, 10% have some college/university education, 45% graduated college/university, and 42% have graduate degrees (See Figure 6).

In general, our survey respondents were very well educated, which may indicate biases in the type of people that choose to take a survey like ours. Additionally, this data revealed no substantial differences in education between the three modes of transportation.

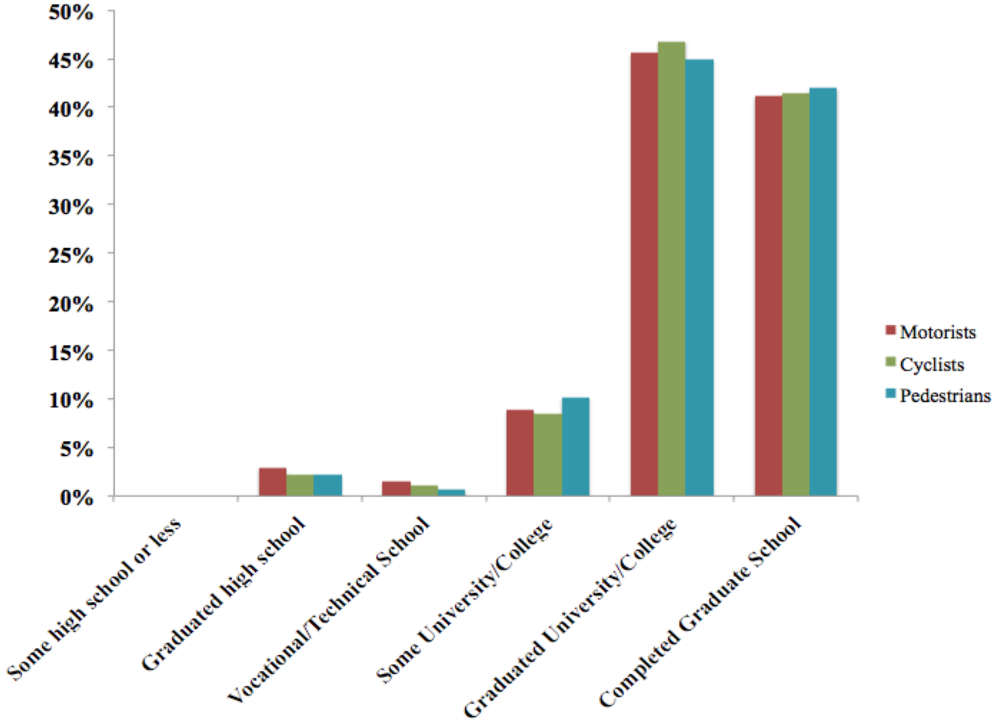


Figure 6: Self-Reported Education Level by Transport Modes

As our motorist focus group suggested, cyclists do tend to earn higher incomes that motorists, though only slightly (See Figure 7). Additionally, the fact that respondents could identify as users of multiple means of transportation may diminish the effect size portrayed here. Ultimately, however, the number of people who are strictly motorists or strictly cyclists is nearly negligible, so the notion of cyclists and motorists being two distinct groups with disparate incomes is largely implausible.

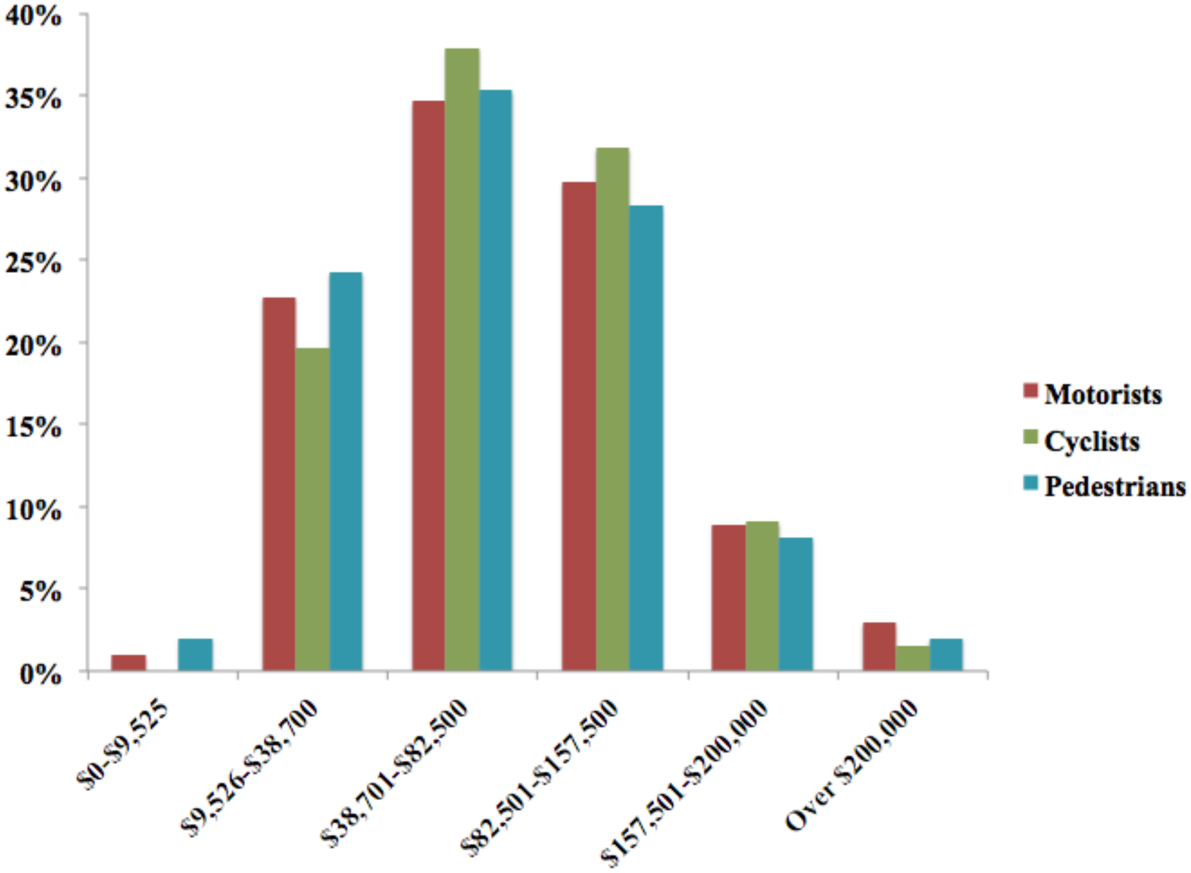


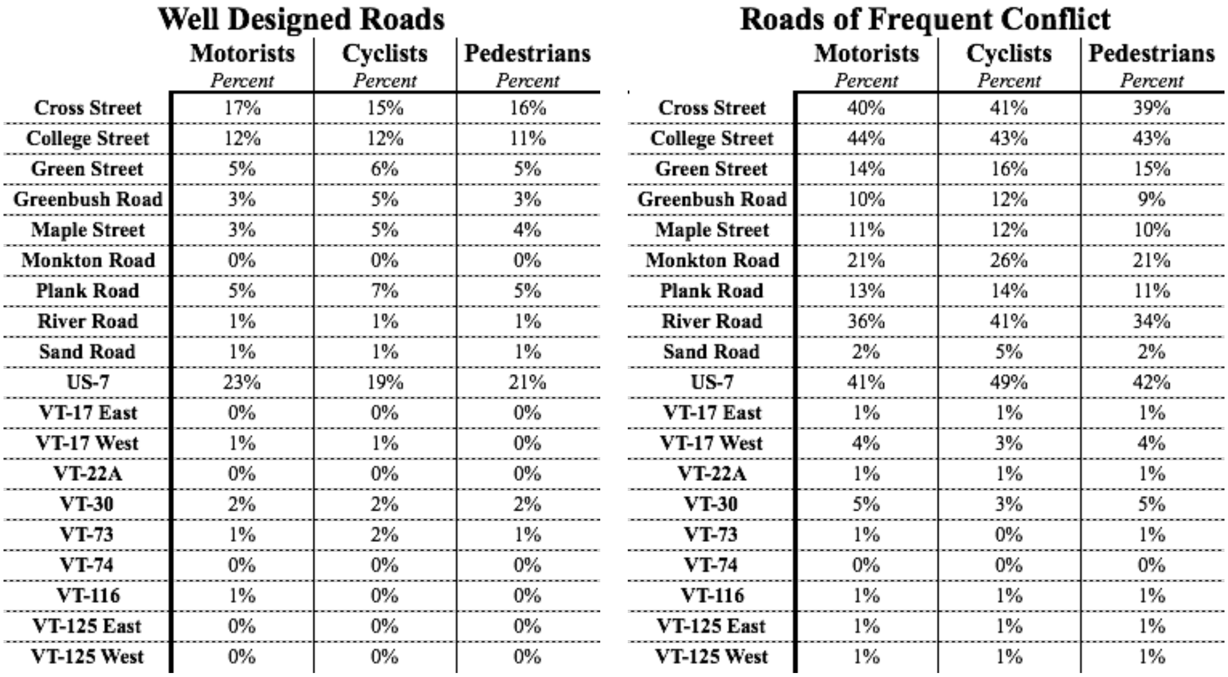
Figure 7: Self-Reported Income by Transport Modes

The survey results regarding well designed shared roads and roads of common conflict between different modes of transportation revealed four town roads (College Street, Cross Street, Monkton Road, and River Road) and one highway (Route 7) that were consistently identified as being common places of conflict (See Table 2).

Incidentally, these routes were among the most frequently identified well designed roads (aside from Monkton Road), though at a much lower rate than they were identified as roads of common conflict between different modes of transportation (See Table 2). It is possible that roads being more frequently recognized as places of conflict between different modes of transportation is a result of it being easier to recall bad interactions on the road than well designed roadways that rarely produce conflicts. Additionally, it is possible that the higher rate of recognizing roads as being places of frequent conflict between different modes of transportation may be a reflection of the quality of Vermont's shared roads, indicating inadequate biking and walking infrastructure along roadways.

The recognition of these routes as being both well designed and areas of frequent conflict between different modes of transportation may be explained by several phenomena. One explanation might be that these routes are the most commonly travelled roads listed in the survey, and therefore more people have adequate information to assess the road as being either well designed or a road of frequent conflict. Another explanation may be that these roads are recognized as being particularly well designed for use by cyclists, motorists, and pedestrians, but the features that make them well designed are not sufficient to mitigate conflicts that may occur.

After identifying survey responses that identified the roads listed above as being both well designed and places of frequent conflict between different modes of transportation, the latter explanation provided above was discounted, as no more than ten respondents identified any of these roads as being both well designed and places of frequent conflict. Further examination of the reason for this phenomenon through surveys and/or focus groups is necessary to determine why some roads are viewed as being both well designed and places of frequent conflict.



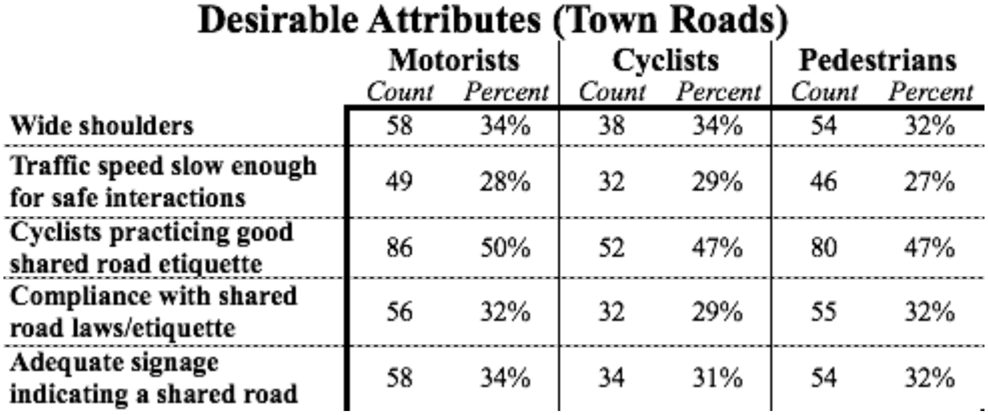
Well Designed Roads

	Motorists *Percent*	Cyclists *Percent*	Pedestrians *Percent*
Cross Street	17%	15%	16%
College Street	12%	12%	11%
Green Street	5%	6%	5%
Greenbush Road	3%	5%	3%
Maple Street	3%	5%	4%
Monkton Road	0%	0%	0%
Plank Road	5%	7%	5%
River Road	1%	1%	1%
Sand Road	1%	1%	1%
US-7	23%	19%	21%
VT-17 East	0%	0%	0%
VT-17 West	1%	1%	0%
VT-22A	0%	0%	0%
VT-30	2%	2%	2%
VT-73	1%	2%	1%
VT-74	0%	0%	0%
VT-116	1%	0%	0%
VT-125 East	0%	0%	0%
VT-125 West	0%	0%	0%

Roads of Frequent Conflict

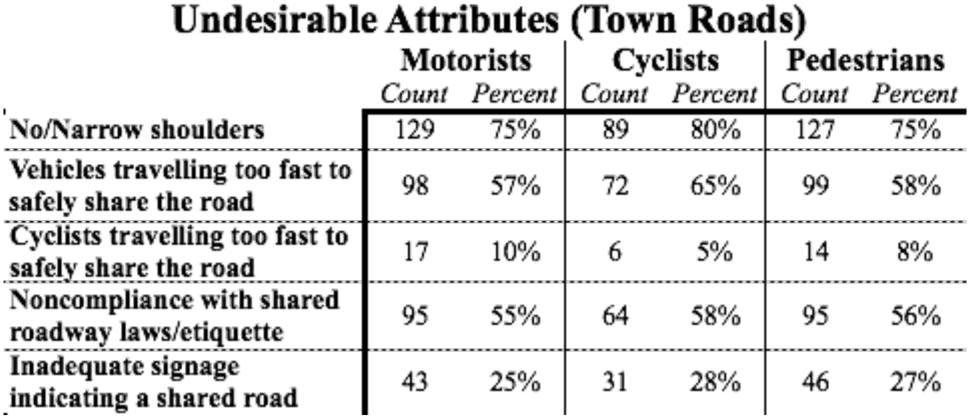
	Motorists *Percent*	Cyclists *Percent*	Pedestrians *Percent*
Cross Street	40%	41%	39%
College Street	44%	43%	43%
Green Street	14%	16%	15%
Greenbush Road	10%	12%	9%
Maple Street	11%	12%	10%
Monkton Road	21%	26%	21%
Plank Road	13%	14%	11%
River Road	36%	41%	34%
Sand Road	2%	5%	2%
US-7	41%	49%	42%
VT-17 East	1%	1%	1%
VT-17 West	4%	3%	4%
VT-22A	1%	1%	1%
VT-30	5%	3%	5%
VT-73	1%	0%	1%
VT-74	0%	0%	0%
VT-116	1%	1%	1%
VT-125 East	1%	1%	1%
VT-125 West	1%	1%	1%

Table 2: Summary of Reported Well-Designed Roads & Roads of Frequent Conflict



Desirable Attributes (Town Roads)

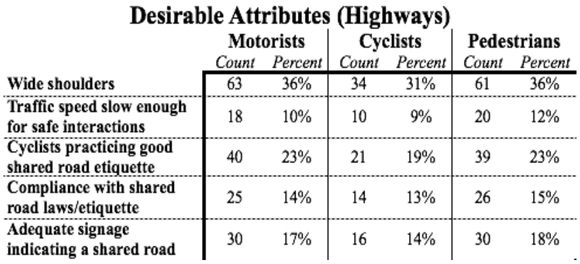
	Motorists		Cyclists		Pedestrians	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*
Wide shoulders	58	34%	38	34%	54	32%
Traffic speed slow enough for safe interactions	49	28%	32	29%	46	27%
Cyclists practicing good shared road etiquette	86	50%	52	47%	80	47%
Compliance with shared road laws/etiquette	56	32%	32	29%	55	32%
Adequate signage indicating a shared road	58	34%	34	31%	54	32%



Undesirable Attributes (Town Roads)

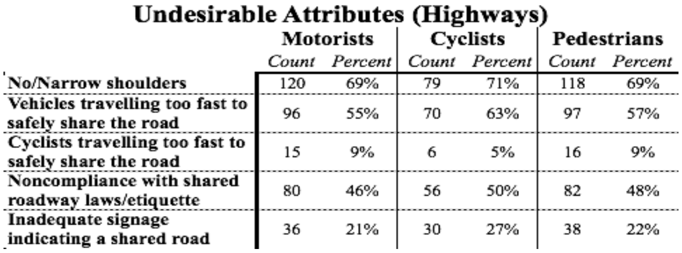
	Motorists		Cyclists		Pedestrians	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*
No/Narrow shoulders	129	75%	89	80%	127	75%
Vehicles travelling too fast to safely share the road	98	57%	72	65%	99	58%
Cyclists travelling too fast to safely share the road	17	10%	6	5%	14	8%
Noncompliance with shared roadway laws/etiquette	95	55%	64	58%	95	56%
Inadequate signage indicating a shared road	43	25%	31	28%	46	27%

Table 3: Summary of Reported Town Roads Desirable and Undesirable Attributes



Desirable Attributes (Highways)

	Motorists		Cyclists		Pedestrians	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*
Wide shoulders	63	36%	34	31%	61	36%
Traffic speed slow enough for safe interactions	18	10%	10	9%	20	12%
Cyclists practicing good shared road etiquette	40	23%	21	19%	39	23%
Compliance with shared road laws/etiquette	25	14%	14	13%	26	15%
Adequate signage indicating a shared road	30	17%	16	14%	30	18%



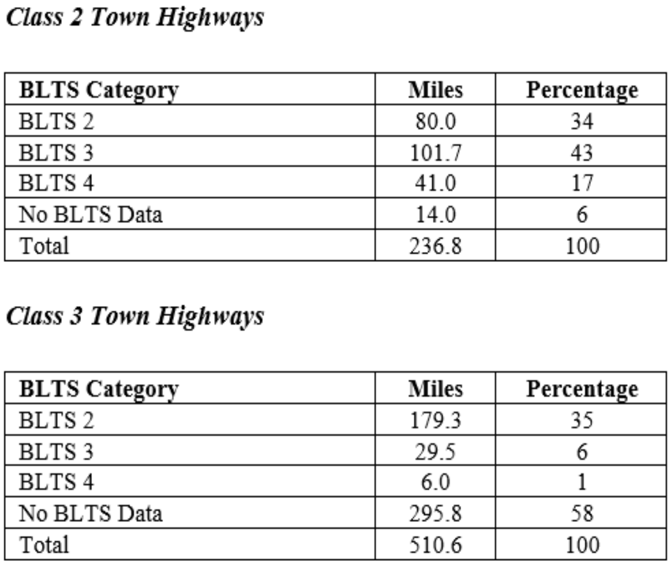
Undesirable Attributes (Highways)

	Motorists		Cyclists		Pedestrians	
	Count	*Percent*	*Count*	*Percent*	*Count*	*Percent*
No/Narrow shoulders	120	69%	79	71%	118	69%
Vehicles travelling too fast to safely share the road	96	55%	70	63%	97	57%
Cyclists travelling too fast to safely share the road	15	9%	6	5%	16	9%
Noncompliance with shared roadway laws/etiquette	80	46%	56	50%	82	48%
Inadequate signage indicating a shared road	36	21%	30	27%	38	22%

Table 4: Summary of Reported State Highways Desirable and Undesirable Attributes

Bike Level Traffic Stress (BLTS) Model

A stress map of Addison County’s local roads can be seen next page (Figure 8) where stress level is coded by color: Green= BLTS 2, Yellow= BLTS 3, and Red=BLTS 4. The prevalence of Green and Yellow is somewhat a good indication that the county's local roads are adequately comfortable for bicycling at least for most adults. Furthermore, Table 5 shows the distribution of segment miles by level of traffic stress with 35% at BLTS 2 for both Class 2 and 3 roads, 18% at BLTS 3, and 6% at BLTS 4. Focus group results confirmed current findings regarding the level of traffic stress for certain road segments. For example, the bicycling focus group participants collectively considered River Road and Monkton Road as particularly dangerous and “bad” for bicycling, which correlates with these roads BLTS 4 scores.



Class 2 Town Highways

BLTS Category	Miles	Percentage
BLTS 2	80.0	34
BLTS 3	101.7	43
BLTS 4	41.0	17
No BLTS Data	14.0	6
Total	236.8	100

Class 3 Town Highways

BLTS Category	Miles	Percentage
BLTS 2	179.3	35
BLTS 3	29.5	6
BLTS 4	6.0	1
No BLTS Data	295.8	58
Total	510.6	100

Table 5: Total Centerline Miles by Level of Traffic

The stress map is useful in identifying "clusters" of low-stress or high-stress roads which could inform or support future transportation planning in certain areas of interest. The main issue with this is that if we only select the most comfortable roads for bicycling, that is BLTS 2, then we would most likely end up with a fragmented network such as the one displayed on a map in Figure 9. This illustrates a typical situation where a person cannot get from Point A to Point B without bicycling on road segments with higher level of traffic stress. While this is a problem, the lack of connectivity might prompt planners to focus on improving roads with BLTS 3 and 4 scores and bring its scores down to BLTS 2.

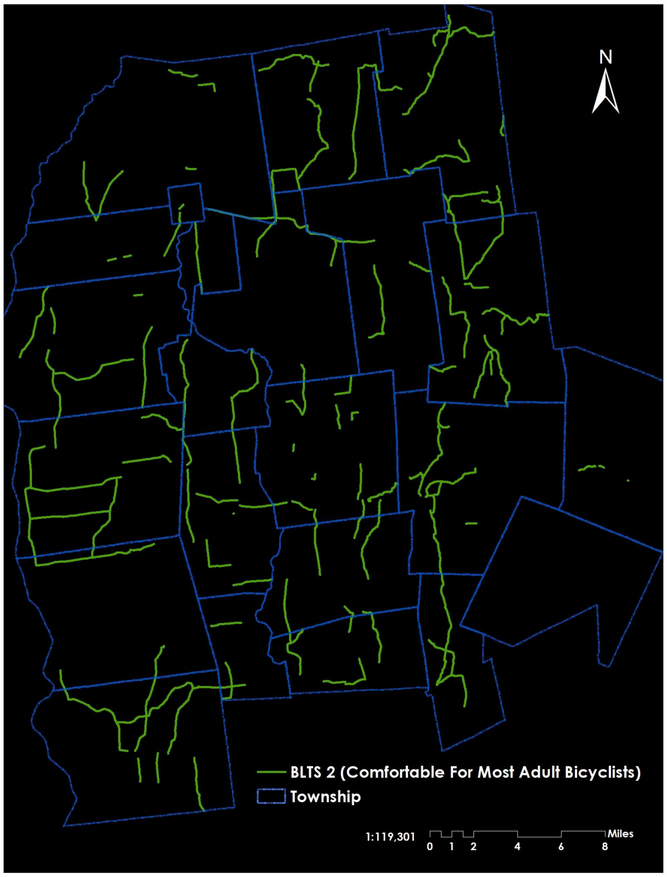


Figure 9: BLTS 2 Stress

This BLTS analysis has many drawbacks due to the data requirement identified by VTrans. The VTrans excluded other traffic parameters, especially traffic speed in their Rural BLTS Criteria which only requires road shoulders, daily traffic volume, and truck traffic data. Speed is particularly important in rural context since rural roads usually have high-speed limits. Therefore, including speed in the Rural BLTS Criteria could potentially make the BLTS analysis more comprehensive and contextually appropriate.

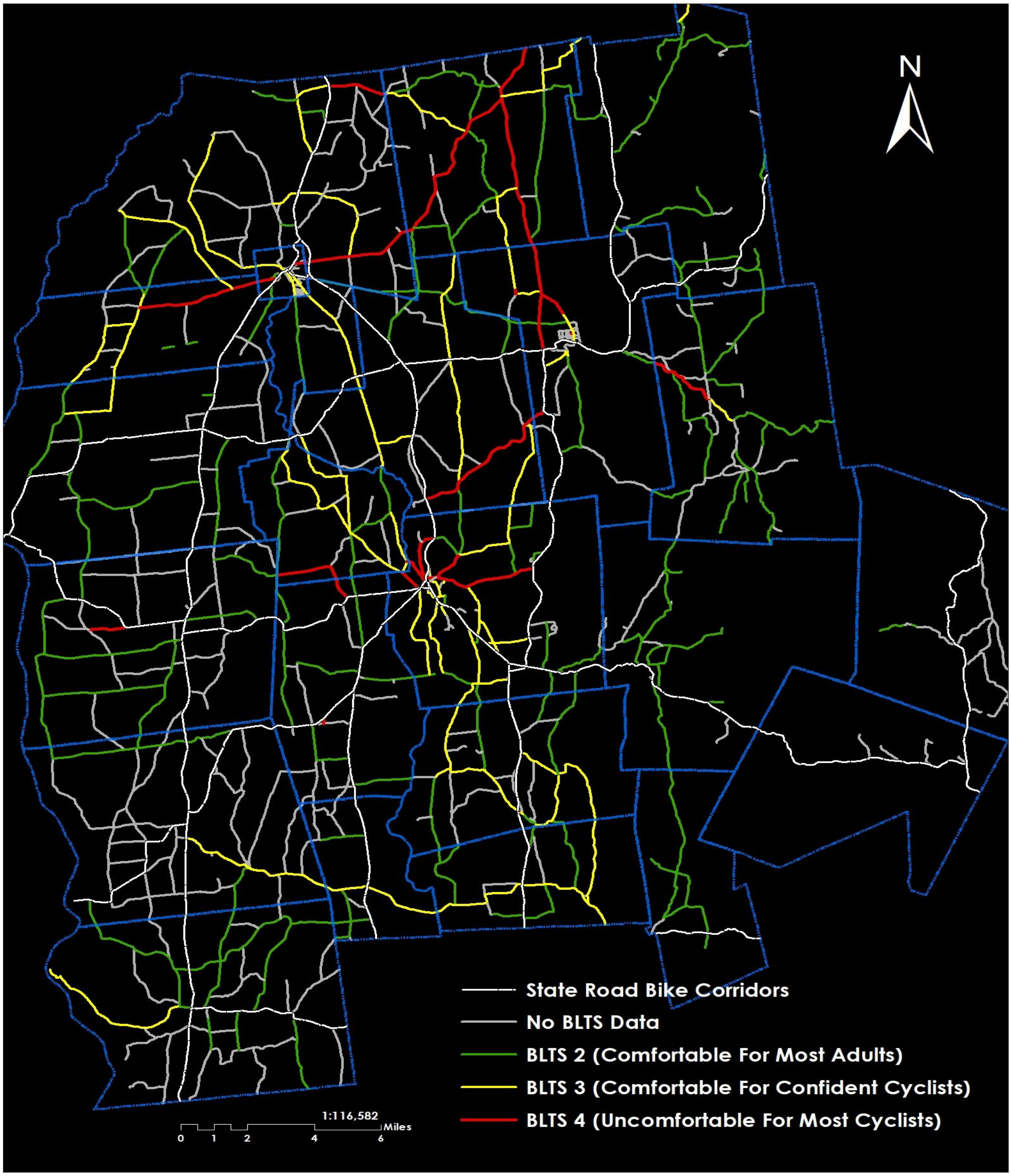

N
State Road Bike Corridors
No BLTS Data
BLTS 2 (Comfortable For Most Adults)
BLTS 3 (Comfortable For Confident Cyclists)
BLTS 4 (Uncomfortable For Most Cyclists)
1:116,582
0 1 2 4 6
Miles

Figure 8: Addison County Stress Map

Tri-Town Biking Loop

Table 6 shows the summary of the prioritization score results. Between Middlebury and Vergennes, **Route Option B** received the highest score of 78.7. Between Middlebury and Bristol, **Route Option A** received the highest score of 78.3. Based on this result, the Tri-Town Biking Loop will consist of the following road segments (See Table 7 and the Tri-Town Biking Loop Map next page).

MIDDLEBURY - VERGENNES

Route Options	Traffic Stress	Topography	Distance	Accident History	Total Score
Route Option A	25.4	22.8	11.2	11.5	70.8
Route Option B	38.2	17.1	14.9	8.6	**78.7**
Route Option C	50.9	11.4	7.4	8.6	78.3
Route Option D	25.4	5.7	3.7	2.9	37.7

MIDDLEBURY – BRISTOL

Route Options	Traffic Stress	Topography	Distance	Accident History	Total Score
Route Option A	50.9	11.4	7.4	8.6	**78.3**
Route Option B	38.2	17.1	11.2	8.6	75.0
Route Option C	25.4	22.8	14.9	5.7	68.8

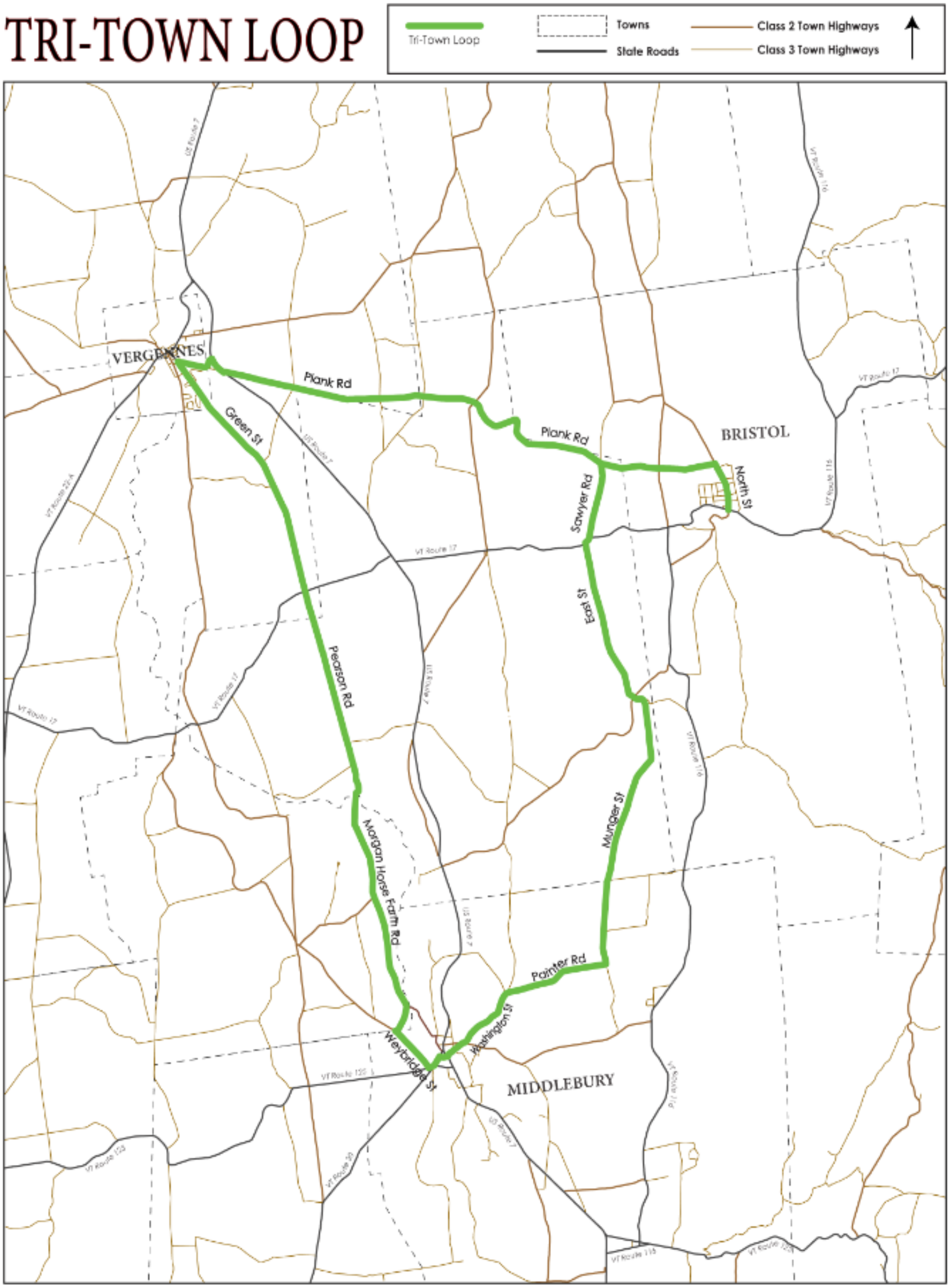
Table 6: Prioritization Calculations

Vergennes - Bristol	*New Haven Rd, Rte 7, Plank Rd, North St*
Vergennes-Middlebury	*Green St, Pearson Rd, Morgan Horse Farm Rd, Pulp Mill Bridge Rd, Weybridge St*
Middlebury-Bristol	*Washington St, Washington St. Ext, Painter Rd, Munger St, Sawyer Rd, Plank Rd, North St*

Table 7: Tri-Town Recommended Biking Loop Road Segments

Biking in between two towns takes less than an hour ranging from 30 minutes to 45 minutes for experienced bikers (See Appendix K for the Tri-Town Biking Loop Assessment). Four experienced cyclists who have local knowledge of the area approved of the results and recommended the designation of the Tri-Town Biking Loop. It is recommended to consult more experienced cyclists to gain better perspectives regarding the safety, security, and comfort while bicycling on these roads.

TRI-TOWN LOOP



RECOMMENDATIONS

This project has collected a suitable sample size of both quantitative and qualitative data on walking, biking, and driving patterns across Addison County. It is hoped that in the future, the results of this study can be utilized in two principal ways: to spur physical infrastructure change and to initiate social and long-term cultural change regarding biking/pedestrian/motorist relations. Accomplishing the first of these, as discussed at length in the results, has a seemingly more concrete course of action. Indeed, through both focus groups and survey distribution, the most pressing needs of Vermont's roads have been identified at length and include, wider shoulders (especially on local roads), more strictly enforced speed limits, and complete street designs which offer an increased number of buffered bike lanes to bicyclists.

Specific roads which need the most attention have been identified through BLTS analysis using GIS software and include College Street, Cross Street, River Road, Monkton Road, and Route 7. Other roads that should be prioritized include those identified as part of the proposed Tri-Town Biking Loop, particularly Plank Road which connects Vergennes and Bristol and currently has a total of 3.39 miles of dirt road between its intersection with North St in New Haven and Burpee Rd in Bristol. Paving this dirt road, would be a simple way to increase bike ridership along this stretch, as it would eliminate dust and mud problems that might currently discourage riders from utilizing it, and would also result in an overall smoother ride for the proposed Tri-Town Biking Loop.

Analysis of the proposed Tri-Town Biking Loop revealed the need for better signage along the route. One area in particular noted by Farid Noori, an avid bicyclist at Middlebury College who tested the loop, is the section coming out of Vergennes which leads cyclists along New Haven

Road to Route 7 in order to cross over to Plank Road headed towards Bristol. Should the Tri-Town Biking Loop be adopted, signage similar to the current signage along the Trail Around Middlebury (TAM) should be utilized in order to assist bikers in identifying the correct roads to ride along between each of the three towns.

The second goal, that the results of this project be used to encourage social and cultural change related to biking, walking, and driving, has a far less clear path to achievement, as this type of change is notoriously hard to induce. The root of this change, ultimately, will be based upon increased education on road use addressing proper cyclist etiquette, such as riding single file when cars are passing and using turn signals, as well as proper driving etiquette, such as allowing sufficient distance from bikers when passing, especially on narrower local roads. It is also important that individuals who identify as bikers, drivers, or both, work to acknowledge and eliminate negative perceptions of each group, particularly with regards to perceived income disparities (i.e. bikers being viewed as individuals who earn more annual income and therefore perceived to be entitled to the road).

Perhaps the key to creating harmony on the roads will come from those who both bike and drive, and therefore have a dual perspective critical to effecting change. Such individuals, which understand the frustration on both sides regarding shared road use, can encourage changes beginning with simple steps such as talking to neighbors using informal gatherings to discuss road etiquette issues. Increased partnership with existing groups focused on bike safety in Addison County, such as Safe Routes to School in Middlebury, might also help to improve strategizing around improving relations between motorists, bikers, and pedestrians on Vermont’s roadways. A more radical proposal would be a requirement that all bikers in the county maintain a license similar to current motorist licenses and complete a mandatory bike safety course before being permitted to use the county's roads.

Additionally, our results suggest that language used on road signs might also play a key role in helping to mediate motorists/biker/pedestrian relations. Indeed, signs that emphasize the human element of biking by using language such as "pass carefully" or signs which emphasize that area is a "bike friendly town" might indicate to all road users that shared road use should be anticipated and accommodated. Based on our research though, which suggests that motorists thought signs were largely ineffective, this proposal would require more research.

CONCLUSIONS

Overall, this project sought to investigate how to best improve the shared roadways of Addison County through a combination of infrastructure improvements and culture shifts. Based on our results, we have recommended several key ways in which the research done by this project can be utilized and believe that the structure of our analysis can be applied to other counties within Vermont as well as rural counties across the country who desire to improve transportation access for all residents regardless of income, ability, race, or gender. It is important that local groups, such as the ACRPC and the WBCAC, as well as larger bodies, such as the Vermont state legislature, continue to carry out similar analyses and begin to make Vermont's transportation network more accommodating, particularly if Vermont aims to achieve the goals set forth in the CEP.

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